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Percept Choice Dynamics of Stochastic Self-Oscillator Model Dominates Percept Reversal Rate Characteristics under Periodically Interrupted Ambiguous Stimulus

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Abstract

A stochastic nonlinear dynamics model is presented which explains published experimental results with periodically interrupted ambiguous stimulus [1][2]. The model is related to the synergetic order parameter approach of Ditzinger & Haken [4] and was recently used for explaining long range correlations of the percept reversal time series [3]. Delayed perception state feedback via an attention control parameter (adaptive gain) is used, which in turn is modulated through a slowly varying bias (memory). A mapping of the perception, attention, memory (PAM) equations to basic Thalamo-Cortical reentrant loops was suggested. Experiments with the Necker cube with stimulus-off times $t_{\text{off}} < 1$ s exhibit a maximum of the percept reversal rate of $R_{\text{max}} \approx 36 \text{ min}^{-1}$ at $t_{\text{off}} \approx 200$ ms (with on-time = 300 ms) [1][2]. According to [1] for $t_{\text{off}} > 200$ ms the percept is stabilized with increasing t_{off} due to recovery from neural fatigue. Within the present model the percept choice or stimulus-onset dynamics during the ambiguous stimulus off-on switching turns out to dominate over fatigue with increasing t_{off} in agreement with Noest et al.[5].

This onset dynamics is induced by the off-on switching of the stimulus ambiguity parameter which correspondingly modulates the feedback. Onset-bifurcation of the perception state at the critical ambiguity parameter value (percept choice) adds to the phase oscillator self-oscillations and to the effects of stochastic attention noise (a fluctuating Langevin force). Numerical simulations are based on the dynamical coupling of the behavioral PAM-variables with delayed feedback. The t_{off} -value at R_{max} and the absolute reversal rate values are determined by the time constants (fatigue, recovery, feedback delay = 40 ms) and by the attention noise power as parameters of the nonlinear PAM-state space equations. A linear approximation in the form of a second order Langevin equation allows for an analytic estimate of the percept reversal rate ($R_{\text{max}} = 30 - 40 \text{ min}^{-1}$) and of the perceptual damping time constant ($\tau_v \approx 1$ s). Within a thermodynamic equilibrium approximation the Fluctuation-Dissipation theorem (or Einstein diffusion coefficient of Brownian motion) relates the noise power spectral density and damping to an index of cognitive inertia and a cognitive perceptual energy value of at least 16 orders of magnitude above the thermal noise level at body temperature.

References

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